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WATERSHED PROGRAM EVALUATION

PLUM CREEK, KENTUCKY

Economic Research Service

and

Soil Conservation Service

UNITED STATES DEPARTMENT OF AGRICULTURE - ERS-243

PREFACE

Plum Creek, a tributary of Salt River, is located in Shelby, Spencer, Jefferson, and Bullitt Counties, Ky. A watershed protection and flood prevention project was authorized for the Plum Creek Watershed on October 7, 1953. This project was 1 of 65 pilot projects authorized for construction on watersheds throughout the United States. Federal funds were made available for installing these projects by the Department of Agriculture Appropriation Act of 1954. Under this authority, a plan of work was prepared by the Soil Conservation Service, in August 1954, for Shelby, Spencer, Jefferson, and Bullitt County Soil Conservation Districts, recommending improvements needed within the watershed. The improvements planned were designed to alleviate soil and water management problems; primarily, the frequent inundation of flood plain lands, soil erosion, and sedimentation.

The Department of Agriculture undertook surveys to evaluate the effects of the improvements installed. This report describes the studies undertaken and sets forth their findings.

This report is the result of the joint efforts of the Kentucky State Conservationist's Office and the Engineering and Watershed Planning Unit, Lincoln, Nebr. (formerly Milwaukee, Wis.), of the Soil Conservation Service, and the Resource Development Economics Division of the Economic Research Service (ERS). Richard A. Blood, Agricultural Economist, ERS, assisted in analyzing the watershed statistics which were collected by William S. Bennett, Agricultural Economist, formerly with ERS.

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Washington, D.C. August 1965

SUMMARY

Benefits quantified from the Plum Creek Watershed Protection Project represent attainments during 1956-60. This short period of evaluation, in contrast to the assumed 50-year project life, is not adequate to verify the benefits estimated in the Plum Creek Watershed Work Plan. In addition to the short evaluation period, smaller amounts of most measures were installed than were recommended, and construction of some measures was not completed until the fourth year of the evaluation period. This may partially explain why the annual benefits from the watershed project, as evaluated, were considerably less than the work plan estimates. Also, due to the overlap of construction and evaluation periods there was no time for farm operators to adjust to the reduced flood hazard.

Reduction in floodwater damages to agriculture during the evaluation period was estimated to be $5,950 annually--$4,460 in crop and pasture damage and $1,490 in other agricultural damage. It was estimated that had all of the watershed improvements been in place prior to 1956, these benefits would have averaged $6,000 and $2,320, annually.

Annual surveys in the sample areas of the watershed indicated a trend toward less intensive land use. Also, these surveys showed that intensity of land use in the flood plain was declining more rapidly than in the upland. Therefore, no benefit from intensified flood plain land use could be identified. Intensification of land use in the flood plain may occur when the farm operators have had a longer period to experience and adjust to the reduced flood hazard.

Revegetation of critically eroding areas was accomplished on 450 acres. When the project was planned, the cost of revegetation was justified on the basis of reduced sediment storage requirements in the floodwater-retarding reservoirs downstream. The evaluation did not include sufficient data suitable for economic analysis of these savings even though sedimentation studies were made of 3 reservoirs. However, yields of forage from the revegetated areas increased from 0.8 to 3.9 animal unit months (AUM) per acre. Used to capacity, these areas would have produced 5.0 AUM per acre, annually. Average annual net benefit to private interests of the 450 acres revegetated was more than $9.90 per acre, or about $4,460. If the Federal costs of revegetating the areas are included, the net benefit drops to $8.20 per acre. In rate of investment return, this has probably been the most successful project improvement applied.

Benefits from prevention of sediment and scour damages were appraised for the storm of June 23, 1960. Benefits from the damage prevented were estimated to average nearly $22 per year for the remaining life of the project. Other geologic studies included: Stream-borne sediment, reservoir-sedimentation rates, reservoir sediment-trap efficiency, and stream channels below 3 floodwater-retarding structures.

Considerable recreational use was made of the reservoirs and their adjacent land. Annual rates of recreational use, in "visitor days," were: Fishing, 5,460; picnicking, 1,200; boating, 300; and duck hunting, 240. Other recreational uses noted, but not quantified, were swimming, trapping, and frogging.

Agricultural uses of reservoir areas, compared with their prior uses, showed little change in intensity, except for land covered by the permanent pools. From 1957-60, the acreage of corn grown in the flood pool areas averaged 40 percent more; pasture, 2 percent less; and hay, 48 percent less than before the structures were installed. No loss in agricultural value occurred in the flood plain areas, even though the acreage of idle land increased.

Gross returns from sales of crops, livestock, and livestock products, computed for all farms having 50 percent or more of their land within the watershed, increased by nearly $8 per acre of total farmland between 1955 and 1960. Survey data were not available for computing the change in production costs, thus change in net income is not known. The increased income takes into account the evaluated watershed project benefits, but it also reflects the impact of all other variables affecting farm income.

WATERSHED PROGRAM EVALUATION
PLUM CREEK, KENTUCKY

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THE WATERSHED

The Plum Creek Watershed, situated in the Kentucky Bluegrass Land Resource Area, contains 23,688 acres.1/ It is approximately 17 miles in length and averages 2 miles in width. The soils of the watershed are derived from limestone with the exception of a small area of marl soils in the west central portion. The topography varies from moderately gentle to rolling slopes in the upper portion, to steep slopes with fairly wide ridge tops in the lower portion. The northern part is used mainly for corn, tobacco, small grains, and hay. The more rolling of the fields are best suited for hay and pasture. In the southern portion, the ridge tops are generally in cultivation, while the slopes are used for pasture or are partially wooded and idle. Most of the flood plain soils are well drained and intensively cultivated.

The economy of the area is predominately agricultural, with more than 98 percent of the watershed in farms. In 1955, a survey of farms having 50 percent or more of their land in the watershed revealed there were 140 farms averaging 168 acres in size. Of the 140 farms, 105 were owner-operated, 33 were operated by tenants, and 2 were operated by part owners. The average land use per farm was: Cropland, 53 acres; improved pasture, 62 acres; unimproved pasture (including woodland), 44 acres; and other uses, 9 acres. These farms had gross sales averaging $6,860, of which more than 53 percent was derived from dairy products; 30 percent, from tobacco; and 14 percent, from beef, sheep, and hogs, combined. Two percent was obtained from sale of crops other than tobacco, and less than 1 percent, from poultry. Twenty-five of the farmers reported off-farm work, averaging 168 days each.

Public roads and waterways occupy 90 percent of the watershed land not in farms; the village of Waterford and rights-of-way occupy the remainder. The watershed population is approximately 700.

Annual precipitation over the 65 years before the project averaged 45.2 inches.2/ From 1938 through 1952, there was an average of more than 3 floods annually, half of them occurring during the summer months. Average annual flood damages during this period were estimated to be as follows:

1/ Soil Conservation Service. Land Resource Regions and Major Land Resource Areas of the United States. U.S. Dept. Agr., Jan. 1963.

2/ Soil Conservation Service. Plum Creek Watershed, Kentucky, Work Plan. U.S. Dept. Agr., Aug. 1954.

Type of damage	Amount
Crops and pasture	$15,928
Scour and deposition of farmland	5,790
Fences, ditches, farm roads, and buildings	19,182
Public roads and bridges	938
Total annual flood damage	$41,838

Improvements made before the beginning of the watershed project include clearing of brush, rock, and drift from 4 miles of main channel of Plum Creek near Waterford in 1949, and the following measures to conserve soil and water:

Contour farming	1,375	Acres
Cover cropping	1,989	do.
Waterway development	38	do.
Pasture seeding	1,020	do.
Fencing woodland	10	do.
Diversion construction	1.7	Miles
Terracing	13.0	do.
Construction of ponds	129	Each

These all helped in alleviating flood, erosion, and sediment problems within the watershed, although no specific evaluations of their effects were made.

THE PROGRAM OF IMPROVEMENT

Program Planned

A program for watershed protection was planned for the Plum Creek Watershed in August 1954.3/ The plan of work was prepared by the local soil conservation districts, with assistance from the Soil Conservation Service. Two groups of improvements were recommended: "A" measures for flood prevention and "B" measures for conservation of water and watershed lands. The A measures recommended were: (1) Floodwater-retarding structures, (2) improvement of the Plum Creek stream channel, (3) subwatershed waterway improvement, and (4) revegetation of critical runoff and sediment-producing areas.

Floodwater-retarding structures were recommended to provide temporary storage of runoff from approximately 31 percent of the watershed. These structures--consisting of earth embankments, outlet conduits, and grassed emergency spillways--were to be designed so that temporary storage capacity would detain sufficient runoff from the design storm to allow nondamaging flow immediately below the dams. The emergency spillways were to protect the structures from storms exceeding the design storm.

3/ (See footnote 2).

Planned improvement of the Plum Creek channel included removal of drifts, sand bars, undergrowth, and overhanging trees, plus intermittent straightening, widening, and deepening.

Subwatershed waterway improvement measures recommended were straightening, sloping, and shaping existing waterways. Farmers were to assume responsibility for seeding and maintaining the waterways.

The remaining A measures were stabilization and revegetation of critical runoff and sediment-producing areas. These included roadside stabilization, revegetation of Class VI and VII land that had insufficient cover to prevent serious erosion, and tree planting on areas which could not be stabilized by grass.

The B measures, which included contour farming, cover cropping, terracing, and waterway development, were planned to reduce runoff from upland areas and to divert it to larger watercourses, thereby considerably reducing erosion. Diversions were recommended to prevent upland runoff from flowing onto or across flood plain areas. Other B measures were pond construction, seeding and improvement of pasture areas, fencing of woodland areas, and changes in the use of land in accordance with its capabilities.

Table 1 lists the measures recommended in the plan of work, August, 1954, and the estimated costs of installation. Costs of developing the work plan and expenses for project evaluation are not included.

Average annual benefits expected to accrue from the planned program of improvements listed in table 1 are shown below:

Type of benefit	Amount
Reduction of floodwater damages	$27,369
Reduction of sediment damages	4,680
Intensification of land use	15,935
Conservation benefits 1/	153,353
Total annual benefits	$201,337

1/ Includes benefits from B-type measures already installed at time of project formulation.

The benefits anticipated from reduction in floodwater damages were estimated to be $11,618 from crop and pasture damage reduction, and $14,969 from reduction of damages to fixed agricultural improvements in the flood plain ("Other Agricultural Damages"). Annual benefit expected from reducing damages to roads and bridges was estimated to be $782.

Benefits from reduction of sediment damages were expected to result from reduced flood plain scour as well as from reduced sediment deposition.

It was estimated that because of reduced flood hazard, farm operators would move higher valued crops to the flood plain and thereby benefit from intensification of land use. One of the most influential of the changes predicted was that some areas of pasture would be planted to tobacco after the project was installed. If all the recommended conservation measures were installed, the increase in net return was expected to average $6 per acre over the entire watershed.

Table 1.--Program of watershed improvements: Recommended in work plan, August 1954, and installed, August 1961, Plum Creek Watershed, Ky.

Watershed improvement measures	Planned: August 1954		Installed: August 1961	
	Quantity	Cost	Quantity	Cost
A measures (flood prevention):		Dollars		Dollars
Floodwater-retarding structures	13	285,863	11	328,394
Stream-channel improvement	21 Miles	37,167	7 Miles	36,859
Subwatershed waterway improvement	95 do.	95,258	19 do.	99,149
Roadside stabilization	12 do.	1,800	0 do.	0
Woodland planting	235 Acres	10,210	32 Acres	2,460
Revegetation of critical areas	450 do.	28,800	450 do.	32,489
Total A measures		459,098		499,351
B measures (conservation):				
Contour farming	5,170 Acres	1,300	2,263 Acres	566
Cover cropping	6,130 do.	39,068	2,365 do.	15,065
Diversion construction	8 Miles	1,688	3.6 Miles	760
Terracing	78 do.	4,056	3.8 do.	197
Waterway development	220 Acres	22,000	152 Acres	15,200
Pond construction	320	48,000	80	17,200
Pasture seeding	2,940 Acres	147,000	5,252 Acres	262,600
Pasture improvement	5,880 do.	117,600	8,806 do.	17,612
Fencing woodland	750 do.	19,500	13 do.	510
Land use conversions:				
Cropland to pasture or woodland	1,519 do.	1/	3,420 do.	1/
Pasture to cropland	3,685 do.	1/	1,646 do.	1/
Idle land to cropland	157 do.	1/	48 do.	1/
Pasture to woodland	255 do.	1/	41 do.	1/
Farm planning and application assistance	22,073 do.	22,000	19,042 do.	25,000
Forest management assistance	3,235 do.	4,165	3,470 do.	4,785
Total B measures		426,377		359,495
Total project 2/		885,475		858,846

1/ When land use conversions required outlays for land clearing, seeding, fencing, or other improvements, such costs were included with costs of other measures.

2/ Excluding the costs of developing the work plan and of project evaluation.

Program Installed

The works of improvement installed under the watershed project as of August 15, 1961, and the costs of their installation are listed in the last 2 columns of table 1. A comparison of these data with the 2 preceding columns shows a divergence between amounts and costs of measures planned and of those

installed. Amounts of measures installed were less in most instances than the amounts recommended in the work plan. For example, 2 less floodwater-retarding structures were constructed than were recommended. The additional structures were not built because the necessary easements could not be obtained. The omission of the 2 structures from the project, and minor design changes in the reservoirs built, reduced the floodwater-retarding capacity from 2,150 acre-feet to 1,781 acre-feet, approximately 17 percent. The area controlled by structures was reduced about 18 percent. Consequently, the floodwater-detention capacity and the area controlled by structures are considerably below the work plan estimate of needs.

Comparing the other A measures: Revegetation of critical areas equaled the amount recommended by the plan of work; stream channel improvement installed was 67 percent less than recommended (this was also a result of difficulties in obtaining easements). Subwatershed waterway improvement was 80 percent less, and woodland planting, 86 percent less than recommended. The planned roadside stabilization was not achieved, as an arrangement to do this could not be worked out with the Highway Department.

In the B group of measures, pasture seeding exceeded the amount planned by 79 percent, and pasture improvement, by 50 percent. However, contour farming was 56 percent less; cover cropping, 61 percent less; diversion construction, 55 percent less; terracing, 95 percent less; pond construction, 75 percent less; and the fencing of woodland areas, 98 percent less. Technical assistance to farmers was 7 percent greater for forestry, and 14 percent less than planned for openland. Conversion of cropland to pasture or woodland exceeded recommendations; however, other land use changes were less than recommended.

EVALUATION OF THE PROGRAM

The program evaluation was designed to measure the physical and economic effects of the installed works of improvement. Accordingly, gages were installed and surveys made to measure streamflow, waterborne sediment, and reservoir sedimentation. The effects of the project on rates of soil erosion and on scour and deposition in stream channels and bottomland were studied. Economic data pertaining to land use, management, and production were obtained from farm operators of selected sample areas. These data, assembled insofar as possible for 1952-60, provide a basis for estimating the effects of installed works of improvement. Surveys to inventory use and organization of the resources available on all farms having 50 percent or more of their land area within the watershed were made in 1955 and in 1960. The major findings and results of the surveys and studies follow.

Flood Plain

Studies conducted concerning the flood plain included: (1) Estimation of the flood reduction effect of the works of improvement; (2) measurement of waterborne sediment in Plum Creek; (3) determination of flood damages; and (4) determination by annual survey of whether flood plain land was used more intensively as estimated in the work plan. The results of the separate surveys and studies undertaken follow.

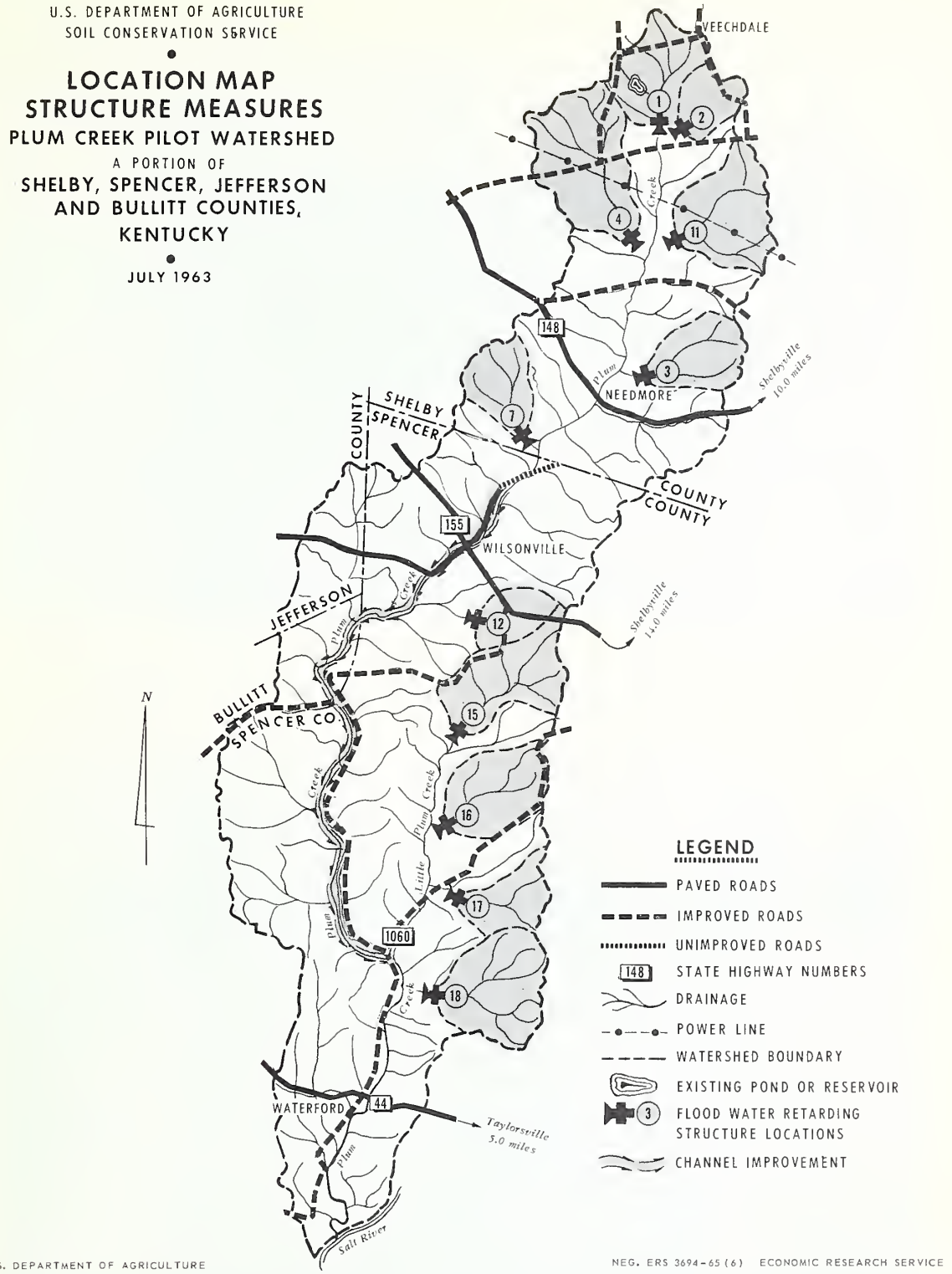

Figure 1.--Location of floodwater-retarding structures and stream channel improvement, Plum Creek Watershed, Ky.

SCS Neg. Ke-126-8

Plum Creek Main Channel Before Channel Improvement

SCS Neg. Ke-192-5

Plum Creek Main Channel After Channel Improvement

SCS Neg. Ke-61-3

Subwatershed Waterway Before Improvement

SCS Neg. Ke-145-7

Subwatershed Waterway After Improvement

Area Inundated

To estimate the area flooded by each storm, precipitation and runoff data were obtained from records of 8 rainfall gages and 3 recording-type stream-gaging stations.4/ Storms producing peak flows that exceeded the base discharges of the 3 stream-gaging stations were analyzed and hydrographs of them were prepared. Their cumulative rainfall and runoff curves were also developed.

Thirty valley cross sections were used to compute the area of land inundated by specific rates of discharge. Twelve "as-built" channel sections were used to determine the hydraulic characteristics of 38,600 feet (7.3 miles) of channel improvement. The channel improvement was completed in July 1959.

The drainage area above the stream-gaging stations was divided into 10 hydrologic-economic reaches. Discharge versus area-inundated curves were constructed for each reach, then summarized and correlated with the corresponding stream gage. Actual discharge was measured for each flood during evaluation period. This discharge reflected the effect of watershed improvement measures installed to that date. Hydrologic calculations were made to estimate the discharge for each flood event, had it occurred under preproject conditions. Utilizing discharge versus area-inundated curves, the area flooded without project measures and the area flooded with project measures installed at time of storm were determined. The sum of the differences in these areas flooded, for each event, make up the flood reduction effect of the watershed project.

Table 2 indicates the area of flood plain land inundated by floods occurring during the 5 years, 1956-60. Acres shown are (1) those which would have been flooded had there been no project measures in place, and (2) those which flooded with project measures installed at time of flood. The difference between the above areas represents the amount of flood plain land which was protected from inundation by the project. These data were prepared for the stream reaches above each of the 3 stream-gaging stations and some adjustments were necessary in combining data for the watershed. However, these adjustments had little effect on the total area inundated.

During the evaluation period, the project measures installed prevented flooding of 1,863 acres of flood plain land. Since the floodwater-retarding structures were not completed until late in the third year and the channel improvement was not completed until the middle of the fourth year, this is a considerable reduction. It was estimated that had all measures been installed at the beginning of the evaluation period, flooding on about 2,900 acres would have been prevented during these 5 years.

Stream-Borne Sediment

Table 3 shows the amount of water-borne sediment passing the Waterford, Ky. sediment-load measuring station from Oct. 1954 to Sept. 1960. The annual amount of sediment passing Waterford decreased during the first 3 years of record, in spite of one storm which contributed 55 percent of yearly total

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4/ Gages were installed and operated by the U.S. Geological Survey.

Table 2.--Area flooded: Plum Creek Watershed, Ky., 1956-60

Date of flood	Area flooded		Area prevented from flooding
	Original--no structures	Modified by installed project	
	Acres		
1956:			
Feb. 2	312	226	86 1/
Feb. 17	361	258	103
Mar. 7	285	208	77
1957:			
Apr. 4	572	447	125 2/
May 21	175	105	70
June 28	372	248	124
Nov. 18	462	351	111 3/
1958:			
Apr. 29	306	184	122
July 11 4/	8	6	2
July 21	401	256	145
Aug. 1	543	417	126
1959:			
Jan. 21	498	395	103 5/
1960:			
Jan. 14	438	236	202 6/
June 23	730	447	283
July 3	461	277	184
5-year total	5,924	4,061	1,863
Average annual	---	---	373

1/ 12.2 percent of the total watershed area regulated by structures as of this date.

2/ 21.6 percent of the total watershed area regulated by structures as of this date.

3/ 23.4 percent of the total watershed area regulated by structures as of this date.

4/ Flooding occurred only on Little Plum Creek.

5/ 25.7 percent of the total watershed area regulated by structures as of this date.

6/ 7.3 miles channel improvement completed prior to this flood.

sediment in 1 day of the third year. For the fourth year of record, the sediment load per acre-foot of discharge increased, as did sediment discharge per square mile of drainage area. This increase was partially because of unseasonably wet weather during August and September. The fifth year of record was unusually dry, except for one 2-day storm that contributed over 87 percent of total sediment for the year. Sediment produced by runoff from this single storm was only about 16 percent less than total sediment measured during the 1956-57 water year. In the sixth year of record, on June 23, 1960, more than

Table 3.--Stream-borne sediment in Plum Creek: Monthly and annual totals, Waterford, Ky., 1954-60

Item	Water year 1/					
	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60
Sediment discharged 2/	Tons					
October	425	2	143	53	117	8
November	4	1,190	15	5,237	51	4,650
December	4,601	367	189	4,726	1,222	3,576
January	154	2,430	2,350	1,195	31,256	17,426
February	18,046	14,610	401	187	861	7,257
March	8,476	7,816	115	327	89	162
April	5,664	124	16,724	5,068	17	27
May	3,505	90	3,042	2,898	29	459
June	517	1,378	2,123	13	39	33,659
July	12,407	89	2	16,920	60	6,588
August	3	45	-	5,885	660	2,742
September	38	124	3	3,227	116	5
Total	53,840	28,265	25,107	45,736	34,517	76,559
Sediment per acre-foot of water discharged	1.78	1.19	1.08	1.13	2.10	2.02
Maximum daily sediment load	6,030	6,450	13,800	6,100	21,100	27,000 3/

1/ Oct. 1 - Sept. 30.
2/ From data collected and compiled by U. S. Geological Survey.
3/ Sediment from storm of June 23, 1960.

35 percent of the year's sediment was measured. This storm was the most severe that occurred during the evaluation period, producing a mean discharge of 3,560 c.f.s. and 27,000 tons of sediment.

Flood Plain Land Use

Gross values of crop and pasture production were used to measure effects of land use changes in the flood plain. Average values of production were computed for the 1952-55 base period, yearly values, for 1956-60, and average values, for 1956-60. Annual flood plain land use and yields for these years are summarized in table 4. Computed gross values of production are shown in table 5. Changes in value of production are associated with changes in land

Table 4.--Land use and average yields in the flood plain, Plum Creek Watershed, Ky., 1952-60

Item	Unit	Average 1952-55	1956	1957	1958	1959	1960	Average 1956-60
Land use:								
Tobacco	Acre	64	51	47	53	45	45	48
Corn	do.	387	355	316	357	410	308	349
Small grain	do.	24	51	23	12	1	26	23
Corn silage	do.	16	59	52	72	42	114	68
All hay	do.	220	169	217	175	189	230	196
Rotation pasture	do.	45	54	47	52	32	21	41
Permanent pasture	do.	114	114	114	110	107	106	110
Misc. cropland	do.	16	13	42	26	13	12	21
Idle cropland	do.	43	71	78	79	93	71	79
Woods, waste, and other	do.	45	37	38	38	42	41	39
Total	do.	974	974	974	974	974	974	974
Average yields:								
Tobacco	Pound	1,603	1,800	1,692	1,225	1,906	1,533	1,622
Corn	Bushel	73	75	67	43	64	29	56
Wheat	do.	24	25	17	30	12	9	20
Corn silage	Ton	11.4	11.7	9.1	9.5	10.1	9.8	10.0
All hay	do.	1.8	2.1	2.1	2.5	2.0	2.0	2.1
Rotation pasture	AUM	2.1	4.5	3.3	2.7	3.3	3.6	3.5
Permanent pasture	do.	1.7	2.6	2.6	2.1	2.0	2.4	2.3

use and yields only, since prices are held constant.5/ However, these values reflect the impacts of flooding and of many nonflood variables on land use and yields. These values indicate lower production in each of the years, 1956-60, than during the base period. If the yield variable is also removed, by using weighted average annual yields (1952-55), the resultant values of production are more nearly a function of land use. Values computed in this manner are also lower in each of the years, 1956-60, than during the base period. This decrease during 1956-60 averaged $10,998, or about an 11-percent decrease from the base period. Therefore, there was no benefit to the project from changed land use in the flood plain during the time covered by this investigation.

Flood Damages

Estimates of flood damage to crops and pasture were made by comparing yields from flood plain fields not flooded, with average yields from all flood plain fields. These differences in yields were attributed to the aggregate effects of the floods that occurred annually from April through November.

5/ Agricultural Research Service and Agricultural Marketing Service. Agricultural Price and Cost Projections. U.S. Dept. Agr., Sept. 1957.

Table 5.--Value of production from the flood plain (computed using long-term projected prices), Plum Creek Watershed, Ky., 1952-60

Item	Average 1952-55	1956	1957	1958	1959	1960	Average 1956-60
				Dollars			
Value computed from observed yields:							
All crops	95,551	92,922	79,015	65,671	86,199	61,872	77,136
Pasture	1,297	2,428	2,032	1,672	1,438	1,294	1,773
Total	96,848	95,350	81,047	67,343	87,637	63,166	78,909
Value computed from 1952-55 weighted average yields:							
All crops	95,551	86,282	79,731	87,784	85,412	83,881	84,618
Pasture	1,297	1,382	1,316	1,333	1,121	1,009	1,232
Total	96,848	87,664	81,047	89,117	86,533	84,890	85,850

Yields and values of production, had no floods occurred during 1956-60, are shown in table 6. Comparison of these production values with the first set of values in table 5 indicates that damaging floods occurred during the crop season in 1957, 1958, and 1960. Damage during these years, based on reduced crop and pasture yields, was $6,896, $13,594, and $20,954, respectively, or $41,444 for 1956-60.

Damage would have totalled $63,758 from the same series of floods had the project improvements not been installed. This estimate was based on the estimated area flooded during the crop season each year, with and without the project. Thus, benefits from the reduction of flood damages to crops and pasture total $22,314 for 1956-60, or an average annual benefit of about $4,460. Had all project measures installed been in place during the entire period, 1956-60, it was estimated that damage reduction benefits to crops and pasture from this same series of floods would have totalled more than $30,000, or over $6,000 annually for 1956-60. Not all of the flood prevention measures were installed, however, until 1959.

During the evaluation period, damages to fixed improvements were determined from surveys of farm operators, following 3 floods. A summary of data obtained by these surveys is presented in table 7. Hydrologic data indicates that these floods inundated a total of 1,150 acres. The aggregate flood damage from the 3 floods averages just over $4 per acre flooded. If we assume this to be representative of all floods during the evaluation period, then project measures (which prevented an estimated 1,863 acres from flooding during 1956-60, table 2) saved approximately $7,450 by reduction of flood damage to fixed improvements during the 5 years, or about $1,490 annually. Again, had all of the project measures installed been in place during the same series of floods, it was estimated that damages to fixed improvements in the flood plain would have been approximately $11,600 less than under preproject conditions, or an average annual damage reduction of about $2,320.

Scour and Deposition

A special study was conducted to evaluate erosion and sedimentation damages in the flood plain from the storm of June 23, 1960, which produced 5 inches of rain in 7 hours and was estimated to approximate a 50-year frequency storm. During and following this storm, the emergency spillway of one of the floodwater-retarding structures operated without appreciable damage.

To evaluate the scour and deposition damages, the affected area of all fields damaged was estimated. The areas damaged by scour appeared to be only in corn and tobacco fields. Damage was noted in 15 fields of which 11 were in corn, and 4, in tobacco, with affected acres totaling 16.4 and 1.2, respectively. Soil losses in the scoured areas averaged 2.7 inches in corn fields and 3.3 inches in tobacco fields.

The bottomland soils are deep and essentially lacking in horizons, so scour damages result primarily from increased wetness rather than loss of natural fertility. Fertility can be affected by scour damage, however, depending on management practices. Tobacco land generally has a winter cover crop, and is fertilized more heavily than corn land; therefore, it suffers some loss of fertility from scour.

Table 6.--Flood free yields and value of flood plain production when no floods occurred, Plum Creek Watershed, Ky., 1956-60

Item	Unit	1956	1957	1958	1959	1960
Average flood free yields: 1/						
Tobacco	Pound	1,800	1,729	1,225	1,906	1,634
Corn	Bushel	75	77	68	64	58
Wheat	do.	25	17	30	12	25
Corn silage	Ton	11.7	10.5	10.5	10.1	14.5
All hay	do.	2.1	2.3	2.5	2.0	2.3
Rotation pasture	AUM	4.5	3.3	2.8	3.3	3.6
Permanent pasture	do.	2.6	2.6	2.2	2.0	2.4
Value of production (long-term prices and flood free yields):						
All crops	Dollar	92,922	85,911	79,192	86,199	82,769
Pasture	do.	2,428	2,032	1,745	1,438	1,351
Total	do.	95,350	87,943	80,937	87,637	84,120

1/ From flood plain fields that did not flood.

Table 7.--Damage to fixed improvements from specific storms, Plum Creek Watershed, Ky., specified dates 1957-60

Fixed improvements	Extent and amount of damage					
	April 4, 1957		July 21, 1958		June 23, 1960	
	Extent	Dollars	Extent	Dollars	Extent	Dollars
Fences	253 rods	593	66 rods	155	641 rods	758
Graded streambank	50 feet	25	-	-	-	-
Levees	125 feet	340	-	-	580 feet	875
Bridges	-	-	-	-	-	700
Buildings and equipment	-	-	-	-	-	640
Miscellaneous	-	-	-	60	-	475 1/
Total		958		215		3,448

1/ Damage to spillway of structure No. 16.

No monetary damages were charged to scour losses of less than 2 inches If there is rapid recovery to prescour elevation, it is assumed that up to 2 inches soil loss is nonconsequential. Flooding could cause loss of fertility in the upper 2 inches through leaching, regardless of scour conditions. The loss would then be considered a floodwater damage.

The scour damages from this storm were estimated to be equivalent to an annual loss in production averaging approximately 7.6 bushels of corn and 49 pounds of tobacco during the remaining estimated life of the project, or 45 years. Thus, computed at long-term prices, the damage sustained from scour as a result of the June 23, 1960, storm will average some $31.60 annually during the remaining life of the project. The rate of damage would be considerably higher during the first few years following the storm and much less during the latter portion of the project's life.

Damages during this same storm from deposition of sand and gravel were slight, being observed in only 2 fields which were planted in corn, and totaled less than one-half acre. Damages to these areas were estimated to be equivalent to a loss in production averaging 4 bushels of corn per acre per year during the remaining project life. Based on long-term projected prices, this is equivalent to a loss of production value from the damaged area averaging $2.61 annually. This damage excludes the cost incurred for removal of large stones, drift, and other debris.

It was estimated that without the project, damages from scour and deposition would have been higher, proportional to the increase in area inundated. Therefore, based on the estimate of acres flooded with and without the project, damages without the project would have averaged about $55.87 annually. Thus, the benefit from reduced scour and deposition damages from this storm will average nearly $22 annually for the remaining life of the project.

Deposition of fine-grained sediment was observed, but was judged to have no effect on crop yields. No instances of damaging deposition or scour were noted in permanent vegetation.

Upland

The principal upland areas studied included the drainage areas above 3 single purpose, floodwater-retarding structures and the critical runoff and sediment-producing areas that were estimated to require revegetation as an aid to flood prevention when the project plan was formulated. These areas included approximately 2,322 acres above floodwater-retarding structures 4, 15, and 17 and 450 acres of class VI and VII land which had little or no vegetative cover at the time of project formulation.

Land Use

Land use and average crop yields were determined from surveys of farm operators in the sample areas. These data were summarized for the 1952-55 base period, determined yearly for 1956-60, and averaged for 1956-60. Table 8 presents land use and yield data for the upland sample areas. Gross values of

crop and pasture production are presented in table 9. These values of production were computed 2 ways, using long-term projected prices (thereby removing price variability). The first values of production in the table were computed using observed yields and land use for each year or period. Values so calculated reflect variability in yields as well as in land use. By using 1952-55 average yields in the second computation, the resultant values of production are a function of land use. These values indicate a lower (average) value of production during 1956-60 than during the base period. This shows that the cropping pattern in these upland sample areas was less intensive since project initiation than before. The values of production, when constant yields were assumed, averaged $4,693 less during 1956-60 than during the 1952-55 base period. This is equivalent to an average decrease of 6.3 percent in the total upland sample. The value of production, however, increased annually since 1958. This indicates that changes, although delayed, are being made toward more intensive cropping patterns. Returns computed for the sample areas indicate higher values of production in 1959 and 1960 than for the 5-year period, 1956-60.

The yield increases in the upland sample areas more than offset the effects of changed land use. This is illustrated in the first computation of value of production in table 9. The value of production from the sample areas during 1956-60 averaged $19,998 more annually than during the 1952-55 base period. Thus, increases in crop and pasture yields compensated for changes in land use, and increased the gross value of production during 1956-60 by 27 percent from the base period. Data available, however, are of inadequate sensitivity to determine what part, if any, of this increase is attributable to the watershed project.

Critically Eroding Areas

It was estimated in the work plan (August 1954) that 450 acres of class VI and VII land were in a critically eroding state with little or no cover. Revegetation with permanent grass cover was recommended. Costs of revegetating these areas were expected to be offset by savings realized from the reduction in sediment storage capacities required for floodwater-retarding structures below the respective areas. Revegetation of critical areas was considered a portion of the A, or flood prevention, measures rather than a land and water conservation measure, and no onsite benefits were claimed.

The evaluation was not designed to make possible an analysis of the benefits accruing to these seedings from reduced sediment deposition in the reservoirs. However, the cost-and-return data collected made possible an analysis of the onsite benefits attributable to these critical-area seedings.

The 450 acres were all seeded during 1955-57. Table 10 shows the total costs, through 1960, of revegetation. Federal expenditures for revegetation of the critical area, done under contract, totaled $22,004 ($48.90 per acre). About 91 percent of the Federal cost was for preparing and planting the critical areas, and the remaining 9 percent was for engineering services. Private interests assumed the cost of land clearing, grass seed, supplemental fertilizer, and supplemental planting. For 1955-60, this totaled $8,813, or $19.58 per acre revegetated.

Table 8.--Land use and average yields in upland sample areas, Plum Creek Watershed, Ky., 1952-60

Item	Unit	Average 1952-55	1956	1957	1958	1959	1960	Average 1956-60
Land use:								
Tobacco	Acre	40	31	33	30	37	42	35
Corn	do.	191	193	165	181	204	232	195
Small grain	do.	54	94	104	59	61	26	69
Corn silage	do.	29	36	36	34	50	44	40
All hay	do.	530	469	462	499	481	513	485
Rotation pasture	do.	227	130	229	251	245	294	230
Permanent pasture	do.	927	981	949	830	777	756	858
Misc. and idle cropland	do.	25	89	48	107	106	55	81
Woods, waste, and other 1/	do.	299	299	296	331	361	360	329
Total	do.	2,322	2,322	2,322	2,322	2,322	2,322	2,322
Average yields:								
Tobacco	Pound	1,887	1,915	1,985	1,723	2,113	1,808	1,911
Corn	Bushel	49	76	61	82	62	85	74
Wheat	do.	25	24	18	17	18	21	20
Corn silage	Ton	7.5	12.9	11.8	11.2	13.8	13.1	12.7
All hay	do.	1.3	2.5	2.2	2.6	1.8	2.2	2.3
Rotation pasture	AUM	1.8	2.2	2.7	3.6	2.7	3.0	2.9
Permanent pasture	do.	1.7	2.7	2.6	3.4	2.7	2.8	2.8

1/ Includes 7.5 acres inundated by the conservation pool of structure No. 15 in 1956; and 3.6 acres inundated by the conservation pool of structure No. 17 in 1957.

Table 11 presents the average yields and average gross value of annual production from the critical areas before and after seeding. The indicated yields after planting include both the yield actually utilized and the estimated total yield per acre, had the areas been used to capacity. Because of the condition of these areas before reseeding, it probably was to the advantage of the project and to the individual farm operators that use was not maximized. The study shows that yields increased tremendously. The average annual yield from the 450 acres before reseeding was 0.8 AUM per acre. After reseeding, the estimated yields averaged 5.0 AUM per acre. Utilized production of these areas averaged 3.9 AUM per acre, 388 percent greater than it was before revegetation.

The average annual value of production from all critical areas increased from $1,625 before revegetation to $7,966 after. The average annual gross benefit through 1960 was $6,341. In the areas seeded each year from 1955-57, the increased pasture yields during the following 2 seasons more than repaid private expenditures. Assuming similar success in reducing soil losses, this measure has probably given the highest return of any in the watershed.

Table 9.--Value of production from upland sample areas (computed using long-term projected prices), Plum Creek Watershed, Ky., 1952-60

Item	Average 1952-55	1956	1957	1958	1959	1960	Average 1956-60
				Dollars			
Value computed from observed yields:							
All crops	65,103	80,935	71,544	77,949	78,372	91,598	80,080
Pasture	8,933	13,206	13,894	16,768	12,413	13,491	13,954
Total	74,036	94,141	85,438	94,717	90,785	105,089	94,034
Value computed from 1952-55 weighted average yields:							
All crops	65,103	58,657	57,687	56,192	63,612	68,420	60,913
Pasture	8,933	8,557	9,120	8,384	7,925	8,163	8,430
Total	74,036	67,214	66,807	64,576	71,537	76,583	69,343

Table 10.--Cost of revegetating critical areas, by type of requirement, Plum Creek Watershed, Ky., 1955-60

Requirement	Quantity	Cost 1/	
		Federal	Private
		Dollars	Dollars
Land clearing	164.5 Acres	-	5,334
Grass seed	10,382 Pounds	-	2,236
Preparation and planting 2/	450 Acres	20,099	-
Supplemental seed 3/	1,751 Pounds	-	560
Supplemental planting and miscellaneous	154.5 Acres	-	683 4/
Engineering services 5/	450 do.	1,905	-
Total cost		22,004	8,813
Average cost per acre		48.90	19.58

1/ These data were developed for establishment of the measure on 10 farms in 1955, 27 farms in 1956, and 22 farms in 1957.

2/ Includes bogging, fertilizing, and planting under contract.

3/ Consisted of grass and legume seed sown during winter or spring to supplement initial seeding of Kentucky 31 Fescue.

4/ Includes the cost of 1,000 pounds of fertilizer applied to 8.6 acres of critical area seedings on one farm in 1959.

5/ Engineering services include Federal cost of planning and supervising.

Amortizing the private costs of revegetating these critical areas over an assumed 10-year life at 6 percent, costs an average of $2.66 per acre, annually. If we assume that these areas are clipped annually for maintenance at a cost of $1.51 per acre, then annual costs to private interests total $4.17 per acre. 6/ The value of average annual production from the critical areas increased from $3.61 per acre before revegetation to $17.70 following revegetation, or $14.09 per acre. Therefore, the annual onsite net benefit to the critical area seedings averaged $9.92 per acre, or $4,464 acres seeded. Even including Federal cost of revegetating the critical areas, the annual net benefit averaged $8.20 per acre revegetated, or $3,690 per year for the total area. 7/

6/ The average cost of clipping pasture in sample areas, 1956-60, was $1.51 per acre. (See "Conservation Measures," this section.)

7/ Federal expenditures from table 10 amortized at 2 1/2 percent over expected life of project. This method assumes private interests will spend an amount equivalent to their original seeding cost each 10 years to maintain or renew grass cover, but that operations performed and/or paid for by Federal funds will not recur during project life.

Table 11.--Yield per acre and value of production of critical areas, before and after revegetation, Plum Creek Watershed, Ky.

Year seeded	Area seeded	Utilized before revegetation: Yield per acre	Utilized before revegetation: Gross value 2/	Utilized after revegetation: Yield per acre	Utilized after revegetation: Gross value 2/	Estimated total 1/ after revegetation: Yield per acre	Estimated total 1/ after revegetation: Gross value 2/
	Acres	AUM	Dollars	AUM	Dollars	AUM	Dollars
1955	55	0.6	148	4.4	1,089	5.1	1,262
1956 3/	228	1.0	1,026	3.7	3,796	4.6	4,720
1957	167	0.6	451	4.1	3,081	5.4	4,058
Total or average	450	0.8	1,625	3.9	7,966	5.0	10,040
Average per acre			3.61		17.70		22.31

1/ Estimated yield and value of pasture production from revegetated critical areas, had they been used to capacity. Data for the 55 and 228 acres revegetated in 1955 and 1956, respectively, are based on estimates for the years 1957 through 1959; data for the 167 acres revegetated in 1957 are based on estimates for 1958 and 1959. Estimates for 1960 were not available for any of the areas.

2/ Computed using long-term projected price derived for Kentucky.

3/ Some uses other than pasture were noted during years prior to 1956 on portions of the 228 acres revegetated in 1956. The yields of these crops were converted to AUM equivalents and are included in the average yield shown.

Upland Erosion

Sediment surveys of structures 4, 15, and 17 indicated sediment was accumulating in these structures at the annual rate of 2.14 acre-feet per square mile of net sediment-contributing area.8/ Assuming a sediment trap efficiency of 94.6 percent and a sediment delivery rate of 73.0 percent, as determined for structure No. 4, soil is being lost above structures 4, 15, and 17 at the annual rate of 3.10 acre-feet per square mile of sediment-producing area. At an average dry weight of 53.7 pounds per cubic foot (calculated as the weighted average of sediment trapped in structures 4, 15, and 17), this represents an annual loss of about 3,626 tons per square mile of net sediment-contributing area of the sample structures. Subtracting the approximately 2 square miles of flood plain, lake surface, and other nonsediment-producing area from the total watershed leaves 35 square miles of sediment-producing area. If sediment production of the total watershed is similar to that in the area above the sample structures, then nearly 127,000 tons of soil are being lost from the watershed uplands each year.

8/ More detailed results of the sedimentation studies are presented later in this report in the section entitled, "Reservoirs and Reservoir Areas."

SCS Neg. Ke-128-5

Field in Critically Eroding State Before Revegetation

SCS Neg. Ke-142-9

View of Field After Revegetation

It was estimated in the watershed work plan that 400,000 tons of soil were eroding from the upland portion of the watershed annually. The estimate of 127,000 tons annual soil loss after project installation is a reduction of more than 68 percent from the work plan estimate. However, these soil losses, averaging nearly 5.7 tons per acre annually, still exceed permissible losses by about 42 percent.9/

Conservation Measures

During the collection of annual data from the sample areas, some data on the amounts and costs of various land treatment measures, including cover cropping, pasture seeding, and pasture clipping, were assembled. Amounts and costs of these measures, quantified from the sample areas, are presented in table 12. Cover cropping and pasture clipping are annual practices while the area of land seeded to pasture is additive for 1956-60. During these 5 years, cover cropping was carried out on an average of 388 acres annually, and pasture clipping averaged 958 acres annually. Pasture seeding in the sample areas totaled 310 acres from 1956-60. The costs of these measures per acre averaged $8.91 for cover cropping, $1.51 for pasture clipping, and $19.18 for pasture seeding. The high cost per acre of pasture seeded in 1958 resulted from a $400 expenditure for land clearing on 15 acres. This cost alone comprised over 60 percent of the total cost of pasture seeding in 1958.

Costs of cover cropping and pasture seeding in the sample areas varied considerably from costs reported for the total project. The unit cost of cover cropping in the sample areas exceeded that reported for the entire watershed by nearly 40 percent; while unit cost of pasture seeding in the sample areas was only about 38 percent of that reported for the total project. One major influence on this variation may be the small sampling of the respective measures. Data from the sample areas represent only about 14 percent of the cover cropping and 6 percent of the pasture seeding. Another influence on the high unit cost of seeding pasture in the watershed may have been land clearing. The cost of pasture seeding in the sample areas in 1958 indicates the effect land clearing costs can have on the total cost. Also, the rate of fertilizer application may have been higher for the total area seeded than was found in the sample areas.

Pasture clipping alone is not considered a separate conservation measure, but may be considered as one of many practices included in "pasture improvement." For this reason, no comparison was possible between the sample areas and the total project.

Reservoirs and Reservoir Areas

Studies and surveys of the floodwater-retarding reservoirs and surrounding areas included reservoir-sedimentation surveys, a sediment-trap-efficiency study, and surveys and observations of stream channels below the sample

9/ Soil Conservation Service. Ready References for Conservation Farm Planning. U.S. Dept. Agr., Milwaukee, Wis., 1959.

Table 12.--Acreage and cost of cover cropping, pasture clipping, and pasture seeding in sample areas, Plum Creek Watershed, Ky., 1956-60

Activity and cost	Unit	1956	1957	1958	1959	1960	Average annual 1956-60
Cover Cropping							
Total area	Acre	573	369	353	173	222	338
Cost for--							
Seed	Dollar	2,229	1,835	1,693	903	992	1,531
Machinery	do.	1,372	1,254	978	738	689	1,006
Labor	do.	741	546	520	194	370	474
Total cost	do.	4,342	3,635	3,191	1,835	2,051	3,011
Cost per acre	do.	7.58	9.85	9.04	10.61	9.24	8.91
Pasture Clipping							
Total area	Acre	873	1,003	1,184	706	1,024	958
Cost for--							
Machinery	Dollar	996	978	1,156	822	1,085	1,008
Labor	do.	425	441	560	335	451	442
Total cost	do.	1,421	1,419	1,716	1,157	1,536	1,450
Cost per acre	do.	1.63	1.41	1.45	1.64	1.50	1.51
Pasture Seeding							Total 1956-60
Total area	Acre	76	171	18	4	41	310
Cost for--							
Seed	Dollar	537	1,430	105	11	255	2,338
Fertilizer and lime	do.	-	1,540	-	12	358	1,910
Machinery	do.	55	557	461	13	157	1,243
Labor	do.	50	238	90	9	68	455
Total cost	do.	642	3,765	656	45	838	5,946
Cost per acre	do.	8.45	22.02	36.44	11.25	20.44	19.18

reservoirs. There were also surveys to determine recreational use of the sediment pools and the agricultural use of the flood pools of all reservoirs. Findings and results of these surveys and studies follow.

Sedimentation Surveys

Surveys to determine rates of reservoir sedimentation were conducted at structures 4, 15, and 17 (table 13). During the period of study, total sediment accumulation in the 3 structures was 27.02 acre-feet. This was an average annual accumulation of 2.36, 2.71, and 1.34 acre-feet for structures 4, 15, and 17.

Loss of sediment storage volume, to date of last sedimentation survey, was 10.9, 18.0, and 16.9 percent for structures 4, 15, and 17. If these sedimentation rates continue, the sediment pools of these structures will be filled at the end of 42, 24, and 23 years, respectively, from their dates of completion. However, the period covered by the sedimentation surveys is short in comparison with the expected life of the reservoirs. Also, slightly higher sedimentation rates are to be expected immediately following construction, until the distrubed areas can be resodded and stabilized. In addition, the frequency of the storms which occurred during the evaluation period may not have been representative of those to be expected during the project's life. The June 23, 1960, storm was estimated to be of a magnitude expected only once in about 50 years. More water-borne sediment was produced during this storm than was measured during the entire 1956-57 water year (table 3). However, giving due consideration to the various causes that may have affected the rates of sedimentation, the storage volume in structures 15 and 17 may be affected significantly by sedimentation. For the sediment pools to last for the 50-year design life, their sedimentation rates would have to average nearly 60 percent less than that measured during the evaluation period.

Sediment-Trap Efficiency

A sediment-trap-efficiency study was conducted at structure 4. The sediment-trap efficiency of a reservoir is defined as the ratio of the amount of sediment retained at the site to the amount of sediment reaching the site. The amount of gaged sediment passing the dam during the 30-month period, April 1, 1956, through September 30, 1958, was used as a basis for estimating the amount passing during a 55-month period for which reservoir-sedimentation surveys were available. From September 1954 (date storage began in structure 4) until April 1959 (date of last complete reservoir-sedimentation survey) 10.82 acre-feet of sediment accumulated in the sediment pool. The sediment was 25 percent clay and 75 percent silt and had a density of 59 pounds per cubic foot. According to the above volume and density measurements, the trapped sediment weighed 13,904 tons.

Sediment outflow at this structure from April 1, 1956, through September 30, 1958, was 433.78 tons. At this rate, the outflow for the 55-month period would be 795 tons. Adding the sediment outflow from the reservoir to that trapped in the sediment pool, 14,699 tons of sediment were delivered to the structure during the period studied, resulting in a sediment-trap efficiency of 94.6 percent. For the same period, it was estimated that 20,128 tons of soil eroded from the lands above this structure. Thus, the reservoir-sedimentation and trap-efficiency studies indicate that 73.0 percent of the soil lost above this structure was delivered to the reservoir.

Table 13.--Summary of findings: Reservoir-sedimentation surveys of 3 sample structures, Plum Creek Watershed, Ky.

Item	Unit	Structure		
		4	15	17
Length of watershed	Mile	2.10	1.70	1.00
Average width of watershed	do.	0.71	0.61	0.56
Range in watershed elevation	Foot	135.5	153.0	176.0
Total drainage area	Square mile	1.50	1.03	0.56
Net sediment-contributing area	do.	1.43	1.02	0.55
Mean annual runoff	Acre-foot	1,365	838	480
Surface area:				
Conservation pool	Acre	13.4	7.7	3.2
Flood control	do.	43.5	19.8	8.7
Storage capacity:				
Conservation pool	Acre-foot	98.9	61.6	30.3
Flood control	do.	302.4	162.7	96.0
Date storage began	Month/year	9/54	9/56	12/56
Date of last complete sedimentation survey	do.	4/59	10/60	10/60
Sediment accumulated as of last survey:				
Total	Acre-foot	10.82	11.07	5.13
Annual average	do.	2.36	2.71	1.34
Annual average per square mile 1/	do.	1.65	2.66	2.44
	Ton	2,120	2,870	2,730
Storage loss, percentage of conservation-pool capacity:				
To date of last survey	Percent	10.9	18.0	16.9
Annual average	do.	2.4	4.3	4.4

1/ Computed from net sediment-contributing area in square miles.

Channel Cross Sections

To determine changes in the channel below floodwater-retarding structures, 17 cross sections of the stream channels below structures 4, 15, and 17 were surveyed in June 1959. These channel sections were resurveyed in December 1960 to determine any changes that had taken place.

During the resurvey of the channel cross sections, scour holes were found below the spillway conduit outlet of each of the 3 structures. Gravel deposits were found downstream from the scour holes. Further downstream some stream-bank

scour was noted below structures 15 and 17. The channel banks below structure 4 were stable.

The holes scoured in the rock bottom channels were, in fact, stilling basins formed where the outflow from the conduits fell on the stream bed. This natural process is less expensive than providing a stilling basin during construction. The gravel deposits observed resulted from material removed from the scour holes and from the natural shaping of the channel banks. Observations indicated that most of the scour and deposition took place during the first few full-conduit flows. Once formed, the gravel deposits should be removed, as a part of the project maintenance program, to eliminate subsequent bank scour at, and immediately below, the deposits. Thereafter, the problem should become insignificant.

Reservoir Areas

Because of the space required for floodwater-retarding structures, their sediment pools, floodwater-detention pools, and emergency spillways, some areas of productive land were completely removed from agricultural use and others were subjected to an increased flood risk. Table 14 indicates the areas of land used for the 11 floodwater-retarding structures and associated areas. Also shown are the crops that were grown on these areas before project installation and the value of products produced. Areas used for the structure sites and for the permanent pools of flood control structures have been lost entirely to agricultural production. Thus, the production loss from these areas would be considered a damage, or negative benefit. If the crops formerly grown in these areas were shifted to other areas and displaced other crops, loss of production (damage) would be the net value of the crop displaced. Following this premise, a parallel can be drawn for the detention-pool areas, where the damage may involve merely the change to a crop of less value with resultant decrease in value of production.

The Interim Progress Report pointed out that a farmer who had grown tobacco in the sediment-pool and dam-site area had shifted this crop to another area of his farm.10/ The loss sustained was the value of the crop displaced, which was undoubtedly considerably less than that of tobacco. Similar shifts of corn displaced by the sediment pool and dam site were also expected. Since it was not known what crops, if any, were displaced, it was impossible to determine the amount of such damage. This damage could range from zero (where crops displaced are transferred to idle cropland) to the value of former production on the inundated and covered areas (no shift in land use--merely loss of productive land and of production).

Table 15 presents land use, average yields, and value of crop production from detention-pool fields for 1957 through 1960, calculated at prices which were current in each of those years. The total acreage shown is 8.6 acres less than that indicated in table 14, which may be because of areas which are located in the channel or in the spillways of the structures, or both. Table 15 indicates that the acreage of corn has increased in the detention-pool areas

10/ Agricultural Research Service. Watershed Program Evaluation, Plum Creek, Kentucky, Interim Progress Report. U.S. Dept. Agr., ARS 43-85, (p. 33), Jan. 1959.

Table 14.--Average land use and value of production before construction of floodwater-retarding structures on 11 sites, Plum Creek Watershed, Ky.

Land use 1/	Sediment pool 2/		Detention 3/		Total	
	Area	Value of production	Area	Value of production	Area	Value of production
	Acres	Dollars	Acres	Dollars	Acres	Dollars
Tobacco	2.9	2,723	-	-	2.9	2,723
Corn	12.8	753	2.0	144	14.8	897
All hay	7.0	182	37.8	882	44.8	1,064
Pasture	26.0	197	53.7	424	79.7	621
Idle, woods, channel	42.1	-	58.7	-	100.8	-
Total	90.8	3,855	152.2	1,450	243.0	5,305

1/ From surveys of all land in reservoirs of floodwater-retarding structures. Data revised from Interim Progress Report, January 1959.
2/ Includes area and production of land in the dam site.
3/ Includes area and former production of land in the spillway.

since the project was installed. The acreage averaged 40 percent greater during 1957-60 than before project installation. However, hay has averaged 48 percent less, and pasture about 2 percent less, than before project installation.

Average crop yields from these fields were surprisingly high, particularly since portions of some fields were inundated. The listing of flood events (table 2) indicates 12 storms from which floodwater detention occurred during 1957-60. Therefore, portions of at least some of these fields were inundated several times during this period. Also, following the storm of June 23, 1960, one structure filled to the point that its emergency spillway went into operation. Even so, yields of crops in the detention-pool areas have averaged nearly as high as in the total upland sample.

Values of production were higher after project installation than before. These values are not directly comparable, since they were computed using prices which were current in each year, 1957-60. However, their relationship would not be affected greatly if converted to a projected price base.

Table 15.--Detention-pool fields: Land use, average yields, and value of production, Plum Creek Watershed, Ky., 1957-60

Item	Unit	1957	1958	1959	1960	Average 1957-60
Land use:						
Corn	Acre	2.0	3.4	2.3	3.5	2.8
Hay	do.	23.7	25.7	7.2	21.5	19.5
Pasture	do.	50.4	47.8	61.9	51.9	53.0
Miscellaneous and idle	do.	19.1	19.5	24.6	25.2	22.1
Woods and brush	do.	48.4	47.2	47.6	41.5	46.2
Total	do.	143.6	143.6	143.6	143.6	143.6
Average yields:						
Corn	Bushel	75	64	53	66	64
Hay	Ton	1.7	1.6	1.7	1.5	1.6
Pasture	AUM	2.4	2.7	2.7	2.4	2.6
Value of production: 1/						
Corn	Dollar	194	261	135	256	211
Hay	do.	907	872	275	758	703
Pasture	do.	484	550	684	504	556
Total	do.	1,585	1,683	1,094	1,518	1,470

1/ Calculated at prices current in each year, 1957-60.

Recreation Benefits

The structures and resulting water impoundments in the Plum Creek Pilot Watershed were planned for a single purpose--floodwater retardation. The normal pool of each structure was designed for sediment storage during the project life, with no additional capacity for other uses. However, data obtained from Soil Conservation Service technicians in the vicinity of the watershed indicate considerable usage of the water stored in reservoirs and of the adjacent land for recreation. Upon completion of the floodwater-retarding structures, the Kentucky Department of Fish and Wildlife stocked each permanent pool with fish, at an estimated cost of $449 for 11 reservoirs.

The detention pools were first used for fishing in 1957, when 3 pools were fished. From April to October of 1957, approximately 250 fishing visits were made to the pool above structure 12, and it was estimated that about 500 pounds of fish were taken. Since 1957, and upon completion of the other reservoirs, all of the floodwater-retarding structures and the areas surrounding them were used for recreation. Annual recreational uses of these structures were estimated as follows: Fishing, 5,460 visitor days; picnicking, 1,200; boating, 300; and duck hunting, 240. These uses were quantified in visitor days even

though actual time spent by each visitor may have been only a few hours. Charges for these types of recreation are generally in terms of an amount per day irrespective of time actually spent. In addition, some of the reservoirs and surrounding areas were used for swimming, frogging, and trapping. No quantification or valuation of these uses was possible.

All of the reservoirs were open to the public for fishing and some owners charged a fee. Boating was allowed on 9 of the reservoirs, however, its interrelationship with fishing was not determined. Nor was the relationship determined between picnicking and other uses such as fishing or boating. The data did not indicate if charges were made for uses other than fishing.

Although from the data it was not possible to compute revenue from recreational uses, a definite recreational value exists from uses made of the reservoirs and surrounding areas. This recreational value is an additional benefit over and above any planned or appraised during project formulation. If, however, the value of recreational uses of the reservoirs is compared to the value of agricultural production prior to the project, only a very low value per visitor day of recreational use is needed to be equivalent to the foregone agricultural production. The gross value of agricultural production was estimated to average $3,855 annually prior to construction of the reservoirs. The recreational use of the project's structures was estimated to be in excess of 7,200 visitor days annually. Therefore, assuming all types of recreational uses to be additive, the recreation need be valued at only about $0.54 per visitor day to be equivalent to the foregone agricultural production in terms of gross income. In terms of net income, recreational uses could probably be valued at an even lower unit cost and still be equivalent to the foregone agricultural production.

Changes in the Agricultural Economy

Economic base surveys of all farms having 50 percent or more of their land area within the watershed project area were made in 1955 and in 1960. These surveys assembled data on number and size of farms, tenure status of farm operators, land use, production, and income from sale of crops and livestock. Information obtained through farmer interviews in 1955 was used to represent the farms before the watershed development program was installed, and data similarly obtained in 1960 was used to represent the area after installation of the program.

Table 16 presents data concerning the characteristics of farms having 50 percent or more of their land area within the project area in 1955 and in 1960. Also shown are changes from 1955-60 in each of the characteristics per farm in absolute numbers and in percentages. The most significant changes apparent in this table are: (1) the tenure pattern of farm operators, (2) the decrease in the area of cropland and increase in area of pasture per farm, and (3) the increase in milk production per cow. A considerable amount of off-farm work was reported by approximately 18 percent of the farmers interviewed in both 1955 and 1960.

Table 16.--Selected characteristics of farms, Plum Creek Watershed, Ky. 1955 and 1960

Item 1/	1955	1960	Change from 1955 to 1960	
			Number	Percent
Farms in the watershed	140	132	- 8	- 5.7
Tenure of farm operators:				
Owner-operated	105	86	- 19	- 18.1
Tenant-operated	33	40	+ 7	+ 21.2
Part owner	2	6	+ 4	+ 200.0
	Acres		Acres	
Average size of farm	168	178	+ 10	+ 6.0
Land use per farm:				
All crops	53	48	- 5	- 9.4
Tobacco	2.3	2.4	+ 0.1	+ 4.3
Improved pasture	62	74	+ 12	+ 19.4
Unimproved pasture 2/	43	47	+ 4	+ 9.3
Other 3/	10	9	- 1	- 10.0
Livestock per farm:	Number		Number	
Cows milked	14	14	0	0
Beef cattle	3	4	+ 1	+ 33.3
Ewes	7	6	- 1	- 14.3
Sows	2	2	0	0
	Pounds		Pounds	
Milk production per cow	5,380	6,890	+1,010	+ 17.2
Off-farm work:	Number		Number	
Farmers reporting	25	24	- 1	- 4.0
Days worked off-farm per farmer reporting	168	176	+ 8	+ 4.8

1/ From survey of all farms that had 50 percent or more of their area in the watershed.

2/ Includes woodland pastured.

3/ Includes idle cropland, woodland not pastured, wasteland, and farmstead.

Land use and gross farm sales from all farms surveyed are presented in table 17. Here again, the decrease in cropland and increase in pasture are the most significant changes in the pattern of land use.

Table 17.--Land use and gross sales, Plum Creek Watershed, Ky., 1955 and 1960

Item 1/	1955	1960	Change from 1955 to 1960	
Land use:	Acres		Acres	Percent
Cropland used	7,397	6,338	- 1,059	- 14.3
Cropland idle	20	106	+ 86	+ 430.0
Improved pasture	8,796	9,718	+ 922	+ 10.5
Unimproved open pasture	4,626	4,764	+ 138	+ 3.0
Woodland pasture	1,398	1,492	+ 94	+ 6.7
Woodland not pastured	145	69	- 76	- 52.4
Wasteland	783	677	- 106	- 13.5
Farmstead	384	385	+ 1	+ 0.3
Total farmland	23,549	23,549	0	0
Gross farm sales:	1,000 dollars		1,000 dollars	
Crop sales	301.6	366.8	+ 65.2	+ 21.6
Livestock sales	177.6	231.0	+ 53.4	+ 30.1
Milk sales	463.8	525.1	+ 61.3	+ 13.2
Other miscellaneous sales	10.0	18.1	+ 8.1	+ 81.0
Total gross farm sales	953.0	1,141.0	+ 188.0	+ 19.7

1/ From survey of all farms that had 50 percent or more of their land area in the watershed. Gross values of farm sales computed using constant, long-term projected prices for both 1955 and 1960.

The area of land in sample farms was 23,549 acres. The area of farmland in the watershed project area was 23,247 acres. As shown in table 17, the increase in gross value of products sold by the sample farms was $188,000, or nearly $8 per acre. This rate of increase when applied to all farmland in the watershed indicates an increase in annual gross farm income of nearly $186,000, from 1955 to 1960. Long-term projected prices were used to compute these values for both years; hence, the returns reflect changes only in volume of products sold. Data available were not adequate to determine how much of the increase would be added net returns, nor how much was attributable to the watershed project. Subject to the evaluation limitations, this increase depicts interplay of all variables which influenced the production of crops, livestock, and livestock products on the sample farms. The complex of influences termed conservation is responsible for part of the change.

Since data were not gathered on an adjacent watershed to be used as a control, the 1954 and 1959 issues of the U. S. Census of Agriculture for Kentucky were consulted for comparison. Almost two-thirds of the watershed lies within Spencer County, and most of the rest in Shelby County. Plum Creek

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Watershed comprises less than 7 percent of the combined area of these counties, and changes which occurred only within this watershed would have only nominal influence on the county statistics. Because of this, census data for these counties were used to estimate changes which would have been expected within the Plum Creek Watershed in the absence of a development project. Cropland acreage decreased 12.3 percent in Shelby and Spencer Counties and, 14.3 percent in the Plum Creek farms. Pasture acreage in the Plum Creek Watershed increased 7.8 percent, while in Shelby and Spencer Counties it decreased 5.8 percent. Value of crop sales in Plum Creek Watershed increased 21.6 percent, but in Shelby and Spencer Counties, only 1.7 percent in a similar 5-year period.

There were 10.9 percent fewer milk cows in Shelby and Spencer Counties in 1959 than in 1954. In the 5-year period beginning in 1955, the number of milk cows on Plum Creek Watershed farms decreased 7.2 percent. The volume of milk sold by Plum Creek farmers increased 13.2 percent during the same period, while the volume of milk sold from Shelby and Spencer County farms increased 25.1 percent. This indicates a smaller increase in milk production per cow in the Plum Creek study area than in Shelby and Spencer Counties as a whole. However, milk production per cow in Plum Creek exceeded the average in Shelby and Spencer Counties by more than 20 percent in the base years. The value of all livestock and livestock products sold increased 40.7 percent in Shelby and Spencer Counties, but in the Plum Creek area, only 18.9 percent.

An attempt was made, through use of county data, to compare the agriculture of the Plum Creek Watershed area before and after the project with what it logically would have been without the project. Because there were so many more variables involved than those influenced by the project, it was impossible to completely isolate those that were project influenced. Consequently, no precise determination could be made of conservation benefits accruing because of the project.

There was no significant difference in the rates at which cropland changed to other uses, nor in the decrease in number of dairy cows, between the Plum Creek sample and Shelby and Spencer Counties as a whole. Farm operators in the Plum Creek Watershed increased the value of their production of crops, livestock, and livestock products by 19.7 percent during 1955-60. In all of Shelby and Spencer Counties, the value of these products sold increased 23.5 percent. Therefore, production increases for the watershed did not differ greatly from the surrounding area without watershed development projects.